SCIENCE

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*FUNCTIONS OF TECHNICAL SCIENCE IN EDUCATION FOR BUSINESS AND THE PROFESSIONS.**

" * * to write now the reforming of education * * * one of the greatest and noblest designs that can be thought on, and for the want whereof this nation perishes. * * *"*—Milton, 'Tractate.'

THE most remarkable and impressive movement of a period which has been well named the 'wonderful century' was one which, from early and feeble beginnings, had been for generations slowly developing, and in rate of motion accelerating, until we to-day see it, in tremendous magnitude and power, affecting every department of human life. This movement causes progressive and cumulative changes in the methods and the products of the labors of the scholar and of the unskilled laborer, of the professional and of the mechanic, of the agriculturist and of the merchant; it changes the views and the studies of the historian, of the philosopher and the psychologist, of the business man and of the educator. It is the advance of the scientific spirit and method into all the fields of human learning and exertion. Scientific method is now dominant in all branches of human life.

This great change commenced with the earliest endeavors of thoughtful men to acquire knowledge by direct appeal to nature and experience. It acquired impetus as the experimental method and the spirit of research began sensibly to enrich our stores of learning and to yield their fine returns in the natural sciences. It assumed its firm grasp upon men's thought and controlled their work when invention and discovery and the upbuilding of new sciences impressed upon the minds of all sorts and conditions of men the fact that its methods were the only direct and sure

* An address at the dedication of 'Engineering Hall,' Iowa State College, May 22, 1903.

ways to achievement. Those methods are simple and even axiomatic in principle.

Science, *scientia,* is knowledge, and its significance became evident immediately it was seen that such an idea is the opposite of speculation, that the determination of a fact and its exact identification by suitable methods was the first step to further and exact knowledge of phenomena, and that this process and its result, the discovery of the laws governing facts in sequence, are the antipodes of the ancient method of primary appeal to the imagination, with later endeavor to find evidence sustaining the fairy tale thus evoked from the inner consciousness.

Wherever work is to be accomplished, the fact is the first requirement preliminary to action, and the controlling law is next to be discovered, in order that it, and every other agency of nature as well as of art, may be directed to the furtherance of the purpose held in view. The scientific method is as fundamental in education as in any other system of application of energy to useful result. A scientific training is an essential, a fundamental, element of all professional education, and systematic training, scientific training, is the direct way toward profitable acquisition and most prompt and complete success.

The scientific method is not restricted to the work of the distinctively so-called man of science. There is a scientific method in history, in the teaching of languages, in theology or in philosophy, quite as definite as in mathematics, chemistry or physics. There is a scientific method of education and of pedagogy. In all cases it simply means the coordination of the two essentials, knowledge, exact and definite, and sound reasoning, the exact acquaintance of the teacher with the fact to be taught, a distinct recognition and formulation of the principles and laws behind the system of facts and phenomena, and systematization of all contemporary knowledge of the subject in such manner as to permit the presentation of all in concise form, in logical order and in perfect symmetry. There is even a 'scientific method of advancement of science';* as of every other department of human knowledge, even of the spiritual in humanity itself.

The mission of science, therefore, in the broadest sense, is the promotion of all human knowledge and, through the extension of learning and of culture, to give wisdom and to offer opportunity for its exercise.† Its direct product is material advance in the industrial system, providing increasing comfort and leisure for the people and, through this improvement in the lives of men, giving opportunity for the development of the intellect, the affections and the soul. But its highest task, though not a more essential element of progress, is the promotion of the efficiency of all our methods of preparing our youth for the 'future of their lives,' as Paley says, 'to perform justly, skilfully and magnanimously, all the offices, both private and public, of peace and war,' as Milton puts it in his specifications for a 'complete and generous education.' In every department such an education teaches first the facts, then the principles and formulated law, and next the system, and finally all practicable applications and illustrations and, where physical manipulations are involved, as in the laboratories, in the gymnasium, in the military academy or in the applications of science in the industrial arts, the utilization by the practitioner of the sys-

* 'The Scientific Method of Science Advancement,' vice-president's address, American Association for the Advancement of Science, St. Louis meeting, 1878, R. H. Thurston.

† 'The Mission of Science,' vice-president's address, American Association for the Advancement of Science, Philadelphia meeting, 1884, R. H. Thurston.

tem thus established. In abstract learning, the principles and the methods of science, as of philosophy, of history, grammar and of philology, are practically applied in the acquirement of further knowledge by the educator and the investigator, and in securing and in maintaining full possession of that learning by the scholar.*

A 'technical education' must be defined before it can be intelligently discussed, and in this discussion it will be understood that by a technical education is meant one that will most effectively prepare the individual to become competent, after experience has had its ripening effect, 'to perform justly, skilfully and magnanimously, all the offices' appertaining to his vocation. His business in life may be commerce or a profession, trade or transportation, education or theology; in each and all, there is a certain essential foundation of exact knowledge, a certain system of principles assuring stability and characteristic form, and another desirable but less absolutely essential quantity of accessory and incidental information and general education and 'culture,' which is needed to give the man that finish and perfection of fitting for the intercourse of man with man which, while not vocational or professional, is none the less an element of real and highest success.

Proceeding to consider the circumstances which determine the form and extent of the technical education of the citizen, the relation of such education to the whole system of preparation by special training for life's special work, it is first necessary to agree upon a definition of the terms technics, technical, technological. The Greek, from which the terms originally come, in the primary and the broadest sense regards these terms as relating to the arts, both esthetic and industrial, and the technique of the artist, of the musician, of the watchmaker and of the steam-engine builder, in each case, infers special talent or special acts appropriate particularly to the art. Technical education, therefore, is a system of instruction devoted to the development of a knowledge of an art, as, for example, taught in a school of music, of law or medicine, of engineering, of theology, or of any industrial department.

Huxley says: Technical education 'means that sort of education which is specially adapted to the needs of men whose business in life it is to pursue some kind of handicraft'; but this definition is obviously narrow. Technical education is admitted to include engineering, for example, which demands a most extensive and most intense preparation, and involves as large an amount of learning, especially in both pure and applied science, as any other vocation —as much as is demanded in the other schools of the 'learned professions,' once distinctively so called. The technical educations include all the educations which fit the man for 'the sequel of his life,' as a member of a working community. But any business career is chosen as a means to an end, and that end should always be the attainment of a competence to insure comfort in old age, and meantime a comfortable life from youth to age, and the privilege of seizing all opportunities for moral and intellectual growth and for becoming of some use in the world. The business education must, therefore, be accompanied by a general education such as will do most to fit the scholar for his place in the social world, and to take advantage of those opportunities which come to all energetic men and women in a country such as ours.

Fortunately, these requirements do not usually conflict or result in inefficiency of

* 'The Miltonian Teaching.' An address delivered at Pratt Institute, Brooklyn, December 11, 1894.

either branch of work. The opportunities which are opened to the average citizen, or to genius, even, in this country, apart from those of the vocation, may be usually seized by any one having the requisite intelligence, ambition and vigor, if possessed of a good common-school education. If such a person needs more, his common-school training will have set him at the beginning of the path, at least, and will have fitted him to move forward, not as easily and rapidly as if under expert instruction, but, as experience has shown in many cases, so as to attain the object of the ambition of the moment. Fortunately, also, whatever the ultimate aim, the beginnings of education must be those which supply the tools with which to construct a career. The education of the primary, and, in large part, of the secondary, school is a preparation for the whole sequence of life, whatever that sequence may become. The arts of reading, writing and computation underlie all arts and all vocations and professions. The languages are the entrance ways to all the literatures. All persons, whatever their aims, must begin by learning the curriculum of the primary school and must usually go on through that of the secondary school. This is, necessarily, all of the nature of education, as distinguished from technical training. Technical science can not be taught effectively, even where essential to the plans and the future of the individual, until a considerable amount of general knowledge has been acquired and the beginnings, at least, of a liberal education supplied. The beginnings being thus acquired, the ambitious man or woman will find ways of supplementing it; the unambitious will forget what has been already gained.

The place for the beginnings in the teaching of technical science, applied science, science in its applications to business, is evidently at the point where the scholar commences his formal preparation for a business life. Yet it is generally the fact that something should be done in this direction in advance of the actual beginning of the business-school work. There is a certain amount of scientific instruction and something of technical, or applied, science needed by all, whether the future is to be a life of scholarly leisure or one of strenuous endeavor in whatever department of industry. Such sciences are, for example, physics and chemistry. These should be taught in the general course, irrespective of the plans of the scholar for the future of his life. Certain sciences, also—botany, for example—have interest for all and are essential parts of the education of the man whose vocation is to be that of the scholar, as well as of the technical training of the naturalist. These classes of subjects are, or should be, taught as electives when the curriculum becomes easy of enlargement in that manner, after the pressure for necessary primary instruction has been relieved. Thus, through all the earlier stages of the education of the citizen, the curriculum is mainly a fixed one, given form by necessity. Time must be devoted to those studies which the child first and most needs as preliminary to all the later education and life. As these are acquired, opportunity gradually reveals itself for the introduction of special and elective courses to be distributed to the pupils in compliance with the demands of their prospective business lives.

At the beginning of this latter period, the place of technical education and of the teaching of technical science comes into view. As the pupil becomes older and his plans for life more definite, the extent and character of the technical science to be taught him become more obvious and more completely known. But the desirable

course is now to transfer him to the school of his trade, or to that which most nearly supplies its place, where expert instruction in every department may contribute with maximum efficiency to the proposed end. If the 'business' to be pursued is commercial, it would seem that the youth should remain in the academic schools just as long as time and money and natural capacity permit, and then he should take up the work of the business or the commercial school. The sciences taught, meantime, in the academic public schools should evidently usually be those which may fairly be assigned to a general course, as being valuable to all citizens. Specialization implied by technical science should be deferred as long as practicable.

When the vocation or the profession is finally chosen, the pupil will demand preparation for the technical or the professional school and, where the demand is sufficiently large to justify it, special arrangements, if necessary, should be made for meeting its requirements. This may mean the establishment of electives for pupils preparing for the academic college, the law-school or the school of engineering. It may mean some substitution of scientific for the usual educational courses where the latter may be safely thus displaced. Those requirements determine the nature and extent of the scientific and of the technical instruction to be introduced. Where the pupil is to go directly into business and his precise line of work is not settled, or where it is evident that he is of that class, large in this country, liable to pass from one vocation to another, the technical sciences of the curriculum should be, in general, the mathematics and the sciences of physics and, particularly, of chemistry. The constant endeavor of our school boards and committees to crowd the whole pantology of an extensive liberal education into a common-school system can never succeed, and the attempt only embarrasses and renders inefficient the work actually squeezed in. If the school is large enough, as often in the cities, it may be practicable to arrange a system of electives, as is done in the colleges, wherever it appears that a sufficient number may be classed together to compensate the specialist to be employed as teacher. In smaller schools this course is usually impracticable.

Education for a vocation being the leading object of any school, its curriculum properly involves mainly those subjects which contribute especially and directly to, and are essential to, its purpose. General education has no place, as such, here, and the student should clearly understand that his education, in the ordinary sense of the term, should be obtained, and as fully and liberally as practicable, elsewhere, and usually previously to taking up the scholastic apprenticeship. The curriculum of the school should include the essential studies, the sciences and the technical information regarding materials and products, processes and apparatus, which contribute to accurate and efficient work and to economical production. There is always a certain sequence which is entirely logical and which settles all questions of order in taking up the various subjects, and this problem is usually non-existent in the technical school. Thus the mathematics must be taken in a fixed order; the applied science must follow the study of the pure science; and physical and chemical and mechanical work must be given after the mathematics have been more or less completely mastered; for, in the technical school, these sciences are quantitative and involve mathematical processes. In this assignment there is no question of the place of these sciences in the work, as the object to be attained fixes all requirements.

The sciences are all, ultimately and necessarily, taught as applied sciences. There is no time, and no needless expenditure can be made, for the acquisition of abstract knowledge when so much is to be learned which is to be utilized directly. It is thus essential to complete success that the teacher be entirely familiar, as an expert, with the applied science. Experience shows that, in the engineering colleges and schools, thoroughly satisfactory work in the sciences is best insured by the selection, as teachers, of talented and interested scientific men who have given sufficient time to the business for which it is proposed to fit the student to become practically familiar with it and with its applications of his science. The pure sciences are as necessarily also best taught by experts, and this means those who have specialized in the sciences commonly taught in the academic departments of our schools and colleges. In fact, the rule that teaching should not be permitted to amateurs, in any branch, least of all in technical departments, should be made universal.

The curriculum should be as obviously constructed by experts in the business to which the school acts as feeder. Only the expert in the business can say what branches of instruction properly constitute the technical plan of instruction. The determination of the character and extent of the technical work in turn settles the question, What sciences and what general instruction must be supplied as a basis for the technical work? The form of the whole scheme of instruction being thus completely fixed, the details should be assigned to specialists, so far as practicable; each to be familiar as an expert with the work demanded of him.

Every business, even purely commercial, involves some connection with the producing industries, and the commercial man should evidently, in each case, have sufficient familiarity with the industry to be able to buy and sell intelligently and to discuss details involving financial interests with his correspondent.

It would seem that, in the individual case, only the student himself can say precisely what kind and approximately what extent of scientific and technical instruction is required by him. The technical school should be prepared to meet the demands of as large a variety of business interests as practicable, after sufficient experience has been had to permit decision. Probably some knowledge of mathematics, chemistry and physics will prove useful to all. Those intending to go into lines of business connected with the iron and steel industries will demand some instruction in the chemistry of metallurgy; those expecting to deal in products of the machine-making arts will need instruction in applied mechanics and machine-design; those about to enter upon commercial work relating to transportation will need some knowledge of the principles of conduct of shipment and construction of invoices.

The whole case, so far as relates to curriculum building, may be put in a few words, thus: The practitioner in the vocation, professional or other, for which educational apprenticeship is to be provided, should decide what sort and how much technical instruction is needed at entrance into that branch of industry. This schedule of required work should be assigned to experts in each of its divisions, to those who have practical and expert knowledge of the business. The requirements being thus ascertained, the next step is to provide for such studies and such tuition as are needed to prepare the student for beginning the prescribed studies. These being introduced, the next lower stratum of subjects is laid out as introductory to the

preceding, and this process is continued until a curriculum is constructed which, leading up out of the common schools, terminates at its superior limit at that point at which the diploma of the technical school or college becomes a sufficient guarantee of satisfactory preparation to enter the business and to perfect the professional education by the regular practice of the vocation chosen.

The final form and extent of this curriculum must necessarily be determined by experience, and the preliminary outline must be accepted as provisional. The curriculum will be subject to constant change, amplification and improvement in detail, as time and the forward progress of the profession or the business permits or compels, and thus the adjustment of the work to the requirements becomes more and more perfect. Ultimately, the practitioner will find that the institution is doing all that can be fairly asked of it, and the novice entering into business will find himself as well outfitted as is possible in the time and at the expense permissible, and the youth proposing to take up the line of work in view will find his progress out of the common school, into the business school or college, and out of the latter into business, a smooth and continuous and clearly defined movement. Once in business, thus prepared, his success will depend upon his own talent, industry, tact and judgment.

This development of our system of general education is the great work of our day and generation. The wisdom of our statesmen as well as of our educators is to be tested, and is being measured by the promptness and effectiveness with which they adapt their own ideas, and fit the educational system, to the requirements of a modern industrial organization. When they stolidly follow the ways of the ancients, modern life flows past them. Modern educations illustrate the wisdom, the learning, the knowledge and the culture of later centuries. The wonderful gains of the nineteenth century, particularly, are being supplemented by those who have the wisdom of great statesmen, the learning of modern times, the knowledge which science supplies and the culture which comes of a symmetrical education in all the arts, the sciences, the literatures and the philosophies of our own time, so far as it has been permitted to incorporate them into school and college curriculums. The extraordinary work of the German empire had its origin, in fact, with statesmen who, without being themselves familiar with the scientific curriculum, were wise enough to understand its fundamental importance and to know its place in the modern educations and the social system.

The nineteenth century has been called the wonderful century; but the world has, since the commencement of the seventeenth century, at least, been progressing with swift acceleration, and each century has been wonderful and each more wonderful than the last, to the contemporary looker-on. The twentieth century is probably to be more wonderful than the nineteenth, not perhaps in the fact of its seeing the inauguration of a new era in science and the arts, that is a wonder, unique and probably without precedent or later rival; but it will no doubt bring its share of new wonders and of new achievement, opening new realms of nature, utilizing new forces and energies, and availing itself of the old in new and unanticipated and marvelous ways. New elements and new compounds are to be discovered having more remarkable and more useful properties than the old; new methods of manifestation of that protean power which we call energy will be observed and utilized in forwarding the tasks of the engineer and strange and mys-

terious phenomena now puzzling all philosophers, 'natural' or other, will find interpretation and application to good works for the benefit of mankind.

In all this the young men now coming into their opportunities, and their successors of the next generations, will have their part and find their opportunity. The progress of the world is still an acceleration, and the gain and the opportunity acquire magnitude as a rapidly increasing function of the elapsing time. The work of the educator assumes constantly higher value and greater importance and commands more respect and larger distinction. The place of the engineer in the world, lofty as it has been in earlier days, when Archimedes and Leonardo and Watt and Fulton and Morse pointed the way to advancement through the union of the sciences and the arts, and high as it is to-day, when its apprentices are coming forward with the learning of the centuries at their command and the skill of the modern mechanic and inventor and the productive power of all modern machinery at their will; it must grow with the advances of the new industrial world until it shall become one which old-world, old-time, kings may well, and in vain, aspire to hold. The engineer must be the general of the industrial army and in his hands be held the fortunes of nations. Those who to-day witness the foundation or the dedication of a noble structure, appropriated to the work of contributing to the education and the professional training and apprenticeship of the young engineer, are witnesses of an event contributing to the highest welfare of the race. Those so fortunate as to be of the generation entering upon this work with the commencement of the new century have the splendid privilege of taking just as large a part in the growing opportunity of the engineer and his army as their wisdom, talent, ambition and energy may permit them to assume. The man, to-day, who has the wit to recognize opportunity and the skill and ability to take advantage of it may fairly expect to go as far and to rise as high as he may choose—always provided he maintains himself in a condition of mental and moral and physical efficiency. For he must make himself a part of the great machine and keep time with its march, and maintain what I am accustomed to call 'maximum commercial efficiency.'

Perhaps, in this day and generation, nothing can more effectively contribute to the weal of the nation than the institution of efficient means of promotion of the work of the engineer and of his profession. As chief of the industrial army of producers of permanent wealth, his wisdom, his knowledge, his culture and his professional efficiency, as derived by the application of talent and wisdom to the improvement of the apparatus and the methods of production, constitute the primary elements of material progress and, through material gain, of the advancement of the nation and of the race.

The progress of the state in all directions is largely influenced by the statesmanship of the people of the state, through the legislation of the representatives of the people in investing available capital in the cultivation of the applied sciences and the encouragement of the universality, the continuity and the efficiency of the industrial system. A people which is thus made in maximum degree industrious, skilful, fruitful, through the exercise of every talent in the most diversified employments, and capable of thus making the industries in highest degree effective in supplying all the needs of the most enlightened community, attains most promptly and completely the highest position in the scale of civilization.

This end can only be secured by systematic and thorough education, not only in the departments of culture, but also of economic production, including, it should be understood, apprenticeship in the professions and the trades. In no department is this more essential than in engineering, where the sciences of mathematics, of physics and chemistry and of construction find their most important uses, and where a perfected economic system must find its directing minds.

This is also quite as true where the interests of the agricultural classes are involved. This intimate relation of engineering and agriculture comes of two principal requirements. First: The energies and the skill and the talents of the people should be so applied in agriculture that the energy of that industry shall be in minimum proportion given to that form of production which directs its powers toward the provision of articles for necessary but, nevertheless, in an economic sense, wasteful expenditure. The products of agriculture are intended to be destroyed, and the less this production of ephemeral forms of product compels a diversion into the work of providing the needed food-products, the larger the proportion of the producing power of the nation to be directed toward the production of permanent forms of wealth. Secondly: The more efficient this thus increased proportion of the producing power of a people can be made, the larger the accumulation and the more rapid the growth of wealth in the community, in its most permanent forms.

Already agriculture is a branch of mechanical engineering.

The responsibility of the state arises out of its duty to promote the welfare of the people of the state. This duty as respects the common school, the free public school, has long been admitted; it is now coming to be seen that higher education to-day is quite as necessary to the highest interests of the state, and even to its industrial progress, as was secondary education when the latter was inaugurated as a fundamental purpose of statecraft, a primary object of legislation. Of these two divisions of this great task of the state, Germany exhibits the finest example of the higher, the United States, of all nations, the most admirable example of the lower. But the higher, and especially the technical, education of all competent to profit by it effectively, is now recognized as an essential which only the state can supply fully, continuously and without distinction of class of citizen.

The state, therefore, inaugurated this work with the enactment by the national legislature of the Land Grant Bill of Senator Morrill, although at the time the nation was engaged in a struggle for life and the civil war was in its most uncertain stage. The several states, following this initiative of the general government, have since assumed their duty, usually in a liberal and enterprising and patriotic spirit, sometimes with apparent reluctance and occasionally evading it largely. In this matter the western states have been usually more statesmanlike than the eastern and fine buildings and noble institutions of learning have marked their progress. In the older states there are larger numbers of colleges already established, often long established and firmly founded by private grants and individual generosity, and there has been less apparent necessity of action by the state, although the essential difference between higher education for the average citizen and that desired by the man of leisure or a member of a so-called 'learned' profession is coming to be seen

and provided for even amongst the most conservative of the older colleges.

In some states the work of the state is carried on by private contributions, in large part, directed, nevertheless, toward the education of the people for life. It is, however, well understood that the work is essential to the progress of the country, and that, on the whole, it is not safe or wise to leave it to the sporadic and fitful care of private benevolence; the duties of the state should never be entrusted to enterprises which are of necessity usually mendicant and unequal to their work as are the colleges generally. The latter are always poor and always more or less inefficient from that cause and they are always necessarily mendicant, receiving their accessions of income irregularly and commonly least freely when most in need. This work must ultimately be mainly carried on by the state to insure thorough efficiency and most rapid advancement of the industries and of the people. There will always be ample opportunity for private means to flow into this form of investment for special purposes; but the state must make it certain that the forward movement of civilization and the advancement of the nation is not permitted to halt because of any lack of provision for education of the coming captains of industry or any defect in efficiency of the means thereto. Every man of genius, whatever his circumstances, will be assured of the privilege of gaining that essential training and learning which only can make his genius of value to the world. It is the state which must provide these 'freaks of nature,' as Huxley called them, these Watts and Faradays and Davys, each genius, according to the great man of science, 'cheap at an hundred thousand pounds.' That nation will go furthest and fare best which produces and utilizes most fully the largest number of these 'freaks of nature.' Our country has, perhaps, produced most freely and utilized most fully; but the time has come when even the man of genius, whether in science or in industry, must, to make his talent effective, know what the world has acquired of learning, and must be trained usefully and effectively to apply that learning by means of the most perfect of all known apparatus and methods. That nation which fails thus to utilize its men of ability will inevitably fall behind, and its people taste of the bitter bread of poverty.

That state which most and best avails itself of the opportunity to establish institutions of higher learning for the promotion, particularly, of the industries, through education for their leading positions of those men of ability, who will invariably seek their opportunities, will find its investment a handsomely paying one. One such man recently saved to the state of New York a million dollars by a single scientific investigation, and every young man leaving the engineering school has his value doubled at the start, and often multiplied many times later, by the training thus provided by the state. The investment is one which pays the state better than any possible purely commercial one can, and the future is far more advantaged than the present and the public at large is profited many-fold by the ability, natural genius trained by scientific method, which is thus gained for its industrial system.

It is not sufficient, however, that the education offered shall be the best possible of its kind; it is essential for its full utilization, that it shall be given by those who are experts, each in his own branch, and, still further, that each of these experts shall be in constant and intimate touch with all the contemporary, and especially the local, industries of the state. Highest

efficiency can not be attained and most prosperous conditions reached by the state unless all the industries are closely and helpfully knit together, and unless every individual in each promotes to the best of his ability the work of each and every other. The state college or university has for its particular opportunity and its especial duty this promotion of the mutual helpfulness of the various departments of industry. Its representation at conventions, its provision of valuable information and its keeping the leaders in the industries well informed of the progress of science and of the arts in directions having interest and importance to them; its scientific researches and attempted discoveries, or its revelations of facts and phenomena having importance in the industries; its finding of the right men for special and important places in which peculiar talent and special training are needed; perhaps more than all, its introduction of new arts and industries and new methods of utilization of natural resources: each and all may advance the best interests of the state inconceivably, and all costs become insignificant in comparison with the benefits derived. This has been true in the past; it will be still more impressively true in the future. It is only the state, however, which can properly carry on this great work and do full justice to the people and to the opportunity.

As between the state and the state college, the obligation is mutual; the college, as the creature of the state, owes to the people composing the state its highest and best work, and always primarily in the interests of the mass of the people and the fundamental industries of the state. The state, on the other hand, owes a duty to the college and, through it, to the people, again: this is the maintenance of the college constantly at the highest possible state of efficiency and fruitfulness by providing it with men and material and suitable accommodations of every sort in such manner that no one member of the staff shall find his usefulness decreased by reason of deficient space, equipment or opportunity to do good work for the state and for the learner.

In meeting these mutual obligations, experience would seem to indicate that it is the state rather than the college which fails of either interest, ambition, earnestness or conscientious compliance with duty. It is oftenest the state which fails to see the opportunity to promote the best interests of the people and to take advantage of that opportunity.

In the hundred or more engineering schools of the United States are about fifteen thousand students, of whom about fifteen hundred pass out into business each year. The growth of these schools has been five hundred per cent. in the last generation, although comparatively few of the splendid private contributions to education of these years have been placed here, where most needed. A few large schools send out the greater part of these young engineers; one third sending out half and more.

A list of one thousand has been prepared for me, tabulated. The average period since 'graduation' is about seven years. Of these, so far as reported, one third are holding positions of independent responsibility; one eighth are managers and superintendents of works; ten per cent. are teaching in the professional schools, and twice or thrice as many are wanted. Ten per cent. are designing engineers, planning the machinery of the workshops, the manufacturing establishments, the railroads, and the fleets of the country. Several are editors; one fourth are manufacturers; many are presidents

and vice-presidents of corporations; others are treasurers, and the balance are distributed throughout the whole system of industries of the country. One half of these men are not above an average of 25 or 28 years of age, and ninety-five per cent. are not above 35 or 37. Practically all retain their connection with their profession. They commonly realize and fully appreciate their advantages, educationally.

One writes, for example, 'The great value of the training given me and especially by the college is brought home to me forcibly many times every day and I prize that training more than all the wealth of the land.'

The severe pruning out of men unsuited to the profession has given these professional schools of engineering the reputation of producing the best-trained of all professional men.

More perhaps than in any other profession is it true that the practitioner, to be successful—which means to be in highest degree useful to the state—must possess a peculiar mental and intellectual make-up. He must unite—at least this is coming to be true very generally if not universally—he must unite that strength of character which every leader must possess, with good sense, such as all men commanding the respect of their neighbors must exhibit, with integrity such as no man can advance without, with thorough professional education and training such as is always essential to professional success. It is further true that the intellectual training of the engineer, for example, furnishes as large opportunity and as great capacity for purely intellectual enjoyment as can possibly any ordinary purely 'cultural' education. Nevertheless, the preparation of the engineer for greatest fulness of life demands cultural study and an extent of learning far broader and deeper than the solely professional. He, like all other men, must for highest results make himself a liberally educated man and must attain wisdom as well as culture, learning as well as technical knowledge, if he is to meet men on a common and lofty ground. It is not enough that he shall make of himself a most efficient machine; he must make of himself a gentleman and a scholar as well as a professional.

The outlook for the young man going out into business of whatever sort from a course of study which has comprehended the elements of a good, sound, English education, college courses which have given him some familiarity with the contemporary literatures and access to the languages in which the thoughts of the masters in his field are immortalized and the practice of his art is exemplified, and from a technical training, a professional apprenticeship, which has built up for him foundations, firm and stable, upon which to raise the structure of his later professional career: the outlook for such a man, if himself well fitted by talent, character and experience to profit by his advantages and opportunities, is now more promising than ever before in the history of the world. The tremendous aggregations of industrial enterprises now coming into form can only be handled by men of more than ordinary capacity, wisdom and experience and only the complete union of the learning of the schools, the judgment gained by experience and the intimate knowledge of the business acquired by the practice of the profession or the vocation, all conspiring with perfect union of the science with the art, will hereafter give highest efficiency in positions of responsibility. The army of industry is now organized and must be officered. Its grades are coming to be as distinctly recognized and established as those of the military or the naval organization, and the

kind of man needed for each grade is as distinctly defined. Every competent man will gravitate to his place; for the head of the army and the chiefs of staff are eagerly looking for that rare and precious character for each position as vacated by the falling out of the incumbent of the moment by retirement or death.

Of the calls which I have received for such men from the 'captains of industry,' 45 per cent. are for positions worth $750 to $1,000, 15 per cent. at $1,200, 20 per cent. at $1,500, 15 per cent. at $2,000, 5 per cent. at $2,500, and in many cases from two to ten men are sought. The needs are greatest in the highest positions and where men capable of carrying large responsibility and having exceptional executive capacity find their place. One man who did not take his diploma for some years after a business call had withdrawn him from his earlier studies is now a vice-president of one of the largest corporations in the United States; another, only about ten years out of college, has become the president of several important corporations aggregating several millions in capital and as a whole extraordinarily profitable, mainly through his ability, good judgment and business efficiency.

One of the best gauges of the value of these men when well suited to their professions is found in the fact that, when these alumni of the engineering college are asked if they desire to change their present positions, they almost invariably reply that they are well satisfied. Asked at what salary a change would be considered, ten per cent. of these giving definite figures proposed $1,000, 30 per cent. $1,500, 30 per cent. $2,000, 10 per cent. $2,500, and 5 per cent. in each grade $4,000, $5,000 and $6,000. The ablest men in highest positions usually declined to consider a change of employers or of employment.

The young engineer, just from college, if he has profited by his opportunities usually gets on slowly at first and very rapidly later. The man who refused $1,500 a year to accept fifty cents a day, where his opportunities were greater for learning his business, now receives—six years out of college—$3,500; the usual figures are $60 to $75 a month when employed rather than taught in the great manufacturing organizations. Salaries a little later range from $1,000 to $3,000 and sometimes $5,000 and $6,000. The average asked by men willing to change their fields of work as reported a year or two ago was about $2,000 for men seven years out of college. One young man dropped out of college to secure an opportunity to become familiar with an important industry, the chance coming unexpectedly. He returned to take his degree, three or four years later, with a contract for four years, at $6,500 a year, in his pocket.

Many become inventors in their chosen fields and accumulate fortunes rapidly. Others enter great enterprises and build up the cotton manufactures of the south; direct the great departments of the electrical industries; revolutionize the methods of production of pig iron; produce a tool-steel capable of multiplying the work of machine tools; invent a steam-engine governor and take in royalties of thousands a month; systematize a gas industry, gaining a fortune while financially benefiting the stockholders and the gas-consuming public; multiply the rate of transmission of intelligence across the ocean, beneath or above its surface; utilize the electrical energies in light and power transmission by new methods; organize new systems and new industrial establishments. All who

thus contribute to the welfare of the people are very sure to secure a handsome commission and scores of these men of the new generation are thus helping others while helping themselves. The conduct of the industries of the country is constantly more and more falling into the hands of the systematically trained and technically learned man.

Young men, such as our best professional schools of engineering are now turning out, are greatly needed and the need is recognized by employers. The demand has been for some years past greater than the supply. A generation ago it was next to impossible to induce the average manager of an industrial establishment to admit the college man within his doors. To-day the same class of men is sought by all, and the larger and the more important the interests involved, the more anxious are the officers of the organization to find men trained in the professional school, combining science with practical knowledge, and prepared to face and to solve the tremendous problems now constantly arising. I have a deep file of letters calling for such men; there is practically none unemployed, unless on the sick-list. All the professional engineering schools are thus situated. Turning out a thousand or more annually, the whole output is absorbed by the great industries and immediately upon leaving the doors of the college. If suited to the profession, success is assured; otherwise, failure is just as certain.

The prizes to be won, like those in all other professions, are large; there is always room at the top; the earnings at first are usually small in cash, large in valuable experience; opportunities come in increasing number if the man is the right man for the higher place; more men are needed than can be found to take the higher positions of responsibility and of commensurate compensation. The wise young professional seeks opportunity for profitable experience without much regard to compensation. I have known a man to refuse a good salary and to accept fifty cents a day, where he saw an opportunity to secure practical experience and training such as, in his estimation, was what he most needed. His spirit was that of Agassiz, who, when asked why he refused an important and lucrative business position, is said to have replied: 'I can not afford to give my time to money-making.' Both had their rewards, each in his own way, in that form of professional success which was the highest ambition of each. Many young college men are to-day working for the great railroad companies, for the electrical companies and for industrial enterprises of all kinds, accepting insignificant pecuniary reward for the time, in order that, by securing that special experience and expert knowledge needed to supplement their special education, they may prepare themselves for positions of honor, of responsibility and of financial value. Here 'the last shall be first.'

It is of little consequence what line of work the young man enters, provided it be that for which he is individually well fitted by nature and training. In mechanical and electrical engineering, in shipbuilding and in the railway system, in mining or in public works, great opportunities are all the time, and more and more frequently, offering. It matters little what line the man selects, provided he is naturally fitted to do the work, by talent and by inclination, and that he acquires promptly the needed professional training and a later experience. If able and reliable and loyal to his employers, he is far more likely to be promoted faster than is desirable than to remain unrecognized in any important organization. His early years should be devoted to securing pro-

fessional knowledge and practical experience, efficiency in his business and ability to deal with other men. Opportunity, responsibility and financial returns will come later, once he reaches the age at which older men holding such positions begin to drop out. If suited to the work he will find his place.

Meantime, the work of the world is falling into the hands of these able, expert, experienced and efficient men of the new generation in rapidly increasing proportion, and the professionally trained engineer now finds himself wanted wherever learning, ability and experience are essential to the success of a great enterprise.

In this great work the student for whom all these sacrifices are made has his part, and his duty is quite as imperative in the utilization of these opportunities as is that of the state to provide them. His first privilege and duty is that of playing his part conscientiously and well. If unable to do the work well that is set before him he should retire to make place for a more competent candidate for opportunity; if found lacking in conscientiousness, he should be retired.

Stradivarius, whose violins to-day will fetch large sums, though they cost but little two centuries ago, in answer to a charge that he worked only for pelf, replied:

"Who draws a line and satisfies his soul,
Making it crooked where it should be straight?
An idiot with an oyster shell may draw
His lines along the sand, all wavering,
Fixing no point or pathway to a point,
An idiot one remove may choose his line,
Straggle and be content; but, God be praised,
Antonio Stradivari has an eye
That winces at false work and loves the true,
With hand and arm that play upon the tool,
As willingly as any singing bird
Sets him to sing his morning roundelay,
Because he likes to sing and likes the song."

The spirit of Stradivarius is that which underlies all success, and not only should the protégé of the state illustrate this spirit as justifying his adoption by the state; but he should understand that the interest and pride and ambition of Stradivarius are essentials of his own later advancement. Thoroughness in college work is no less essential and fundamental an element of success with the individual than is the success of the outgoing army of alumni vital to the progress of the country and the growth of the state in all that makes success for the people, or that makes life worth living for the dweller in their midst. Given this spirit of wholesome and cheerful ambition and the atmosphere which it engenders, and the world will be the better and the brighter each day.

Our own progress as a nation depends upon the wisdom and foresight, the patriotism and courage and persistence of our own educators and statesmen and industrial leaders. With wise statesmanship, our own nation may become the leader of the world and our country may always move onward in the van of modern progress. At the moment, what is most needed is the awakening of our legislative and executive officials to the duties and the opportunities of the times. It is the fossilized educator and the ignorant and unpatriotic politician, and the demagogue who aspires to lead 'labor,' and the educated man with his head in the clouds, who are the most serious obstacles to the progress of education, and to that of the nation toward higher and better things. These classes being either enlightened and purified, or extinguished, we may trust the American people to take full advantage of their opportunities and to hold a foremost place in the peaceful rivalry of the nations.

ROBERT H. THURSTON.

SIBLEY COLLEGE,
CORNELL UNIVERSITY.

*ROYAL SOCIETY CONVERSAZIONE.**

THE first of the two Royal Society *conversaziones* has been held at the society's rooms in Burlington House. There was, as usual, a large attendance, the visitors being received by the president, Sir William Huggins.

The exhibits seemed to be more numerous than the average, and, on the whole, each had a wider range than last year. Exhibits in the departments of physics and chemistry predominated, electricity and its applications being prominent. Naturally, special interest was manifested in the new coherer as applied to wireless telegraphy, shown by Sir Oliver Lodge and Dr. Alexander Muirhead. The coherer consists of a steel wheel which rotates so that its edge touches a pool of mercury through a film of oil, the decoherence being automatic. A fraction of a volt is used in the detecting circuit, which works a siphon recorder as the receiving instrument. The sending post of the station was also shown. It ought to be noted that some years ago, at a Royal Society *soirée*, Sir Oliver Lodge exhibited an arrangement for wireless telegraphy, of which this may be regarded as the parent stage. Sir Oliver Lodge is devoting himself rather to the perfection of his arrangement than to the attainment for the present of long distances. Another exhibit which naturally attracted much attention was that by Sir William Crookes, illustrative of the properties of the emanations of radium. There were autoradiographs, photographs of radium emanations, luminous effects of radium emanations, and an ingenious little instrument which Sir William Crookes calls a spinthariscope, intended as a convenient contrivance to show the scintillations of a piece of radium nitrate. A solution of radium on a small plate formed a permanent lamp, which might really be of practical use.

Included among other exhibits of an electrical character may be mentioned the Rev. F. J. Jervis-Smith's high-pressure spark-gap, consisting of a thick glass globe furnished with two platinum-faced balls, adjustable for distance, used in connection with an inductor of the Tesla type, and also in connection with a radiator of Hertzian waves. Mr. A. Williams showed some brilliant experiments to illustrate a method, by means of a shunt, of controlling and regulating spark discharges, so as to make them more regular and more under control for therapeutic and wireless telegraphy purposes.

Dr. W. Ramsden's experiments, to demonstrate the presence and spontaneous formation of solid membranes upon the free surfaces of certain solutions, were striking, and some of the results, including micro-photographs and microscopic specimens, were very beautiful. Mr. Joseph Goold's diagrams, illustrating the order and origin of the musical scales, showing that the system of sounds commonly employed in written music is dual throughout, were remarkable. Mr. A. E. Tutton exhibited an elaborate arrangement which he calls an elasmometer, for the determination of the elasticity of solid substances, particularly crystals, which can not be obtained in very large pieces. Mr. W. Watson's light mirrors suitable for galvanometers are made of fused silica, the reflecting surface consisting of a film of platinum. An experiment by Mr. O. W. Richardson illustrated the conductivity imparted to a vacuum by hot carbon. Dr. Common exhibited a collimating gunsight for use by day and night, consisting of a lens mounted in a tube fixed at the top or side of the gun, with a fiducial mark at its focus, the mark being a black spot for day work or a small luminous red spot for night work. Dr. Common also showed an optical sight

* From the London *Times*.

for guns and rifles, and a spherometer of great delicacy. The Rev. John Bacon's aerial photographs were extremely interesting. They were obtained recently from balloons in unique circumstances. Mr. T. Matthews showed some incandescent oil-burners which have been designed by him, primarily for use in the Trinity House lighthouse service. The arrangement, like that of most of the other exhibits, is too elaborate to be understood by mere verbal description; but it may be stated that the intensity of a single mantle burner for flashing lights is 1,100 candles, and the consumption of oil one pint per hour, while the intensity of a triple mantle-burner, for fixed and occulting lights, is 2,700 candles, and the consumption of oil three pints per hour.

From the Solar Physics Observatory, South Kensington, were photographs illustrating a comparison of the arc spectra of various samples of dust, showing what chemical elements are represented in the samples. There were also some very interesting and convincing curves illustrating the long-period solar and meteorological (rainfall) variations of about thirty-five years. As might have been expected, a number of exhibits were connected with the recent destructive volcanic phenomena in the West Indies, which were investigated by a commission sent out by the Royal Society. There were a number of photographs illustrating the late eruptions in St. Vincent and Martinique and also specimens of the volcanic dusts, ashes and other *ejecta* of the West Indian volcanoes. It need hardly be said that Mr. Arthur J. Evan's exhibit illustrative of the excavations at Knossos, in Crete, deservedly attracted considerable attention. The exhibit consisted of a general plan of the Palace.

There were a considerable number of biological exhibits, which can only be briefly alluded to. Deserving of careful study are the results of the experiments shown by Miss E. R. Saunders illustrative of what she calls structural atavism, resulting from cross-breeding in plants. Dr. A. Macfadyen and Mr. S. Rowland, of the Jenner Institute of Preventive Medicine, illustrated their methods of disintegrating cells and micro-organisms and of obtaining their intracellular constituents. Dr. Alan B. Green had an exhibit illustrating the method of preparation of chloroformed calf lymph, from the government lymph laboratories. Dr. G. H. Fowler showed specimens of a remarkable radiolarian, differing in structure from all other forms hitherto described, and Dr. H. Gadow a very beautiful illustration of the development of the color pattern in Mexican species of lizards and a convincing illustration of the influence of environment. The five specimens of sea snakes that swarm round the coasts of India and in other tropical seas, exhibited by Dr. Leonard Rogers, their poison being more powerful than that of any other snakes, though interesting in their way, can hardly be said to have been attractive. Miss Dorothy Bate showed the remains of pygmy elephant and pygmy hippopotamus, obtained from caves in Cyprus.

The exhibition by means of the lantern of Sir Benjamin Baker's magnificent slides illustrative of the Nile Dam works, it need hardly be said, met with universal admiration. Dr. Cantellani's specimen of Trypanosoma, found in sleeping-sickness patients in Uganda, should be mentioned. There were many other exhibits in the rather crowded rooms, all of them illustrative of important scientific work.

SOCIETIES AND ACADEMIES.

NEW YORK ACADEMY OF SCIENCES.
SECTION OF BIOLOGY.

A REGULAR monthly meeting was held at the American Museum of Natural History

on May 11, Professor Bashford Dean presiding. Papers were presented by Professor H. F. Osborn, Professor E. L. Thorndike and Mr. C. T. Brues.

Professor Osborn's paper, 'On Recent Models and Restorations of a Number of Extinct Animals, with a Discussion of their Probable Habits and Mode of Life,' was based upon models and restorations from the Department of Vertebrate Paleontology of the American Museum of Natural History, prepared by Charles Knight under the direction of the speaker, with the assistance of other members of the department. Numerous models and drawings were exhibited and described. Of special interest were the following: *Elephas imperiales* (Imperial mammoth); *Trilophodon productus* (Miocene mastodon); an *Ichthyosaurus* and young; several Pleistocene rhinoceroses; and *Diplodocus* (a bird-catching dinosaur).

Professor E. L. Thorndike, on 'Natural Selection and Fertility in Man,' reported a study of the size of families of college graduates during the nineteenth century, and of the descendants of a New England family during the eighteenth and nineteenth centuries. The average number of children in the latter case rose gradually to an acme in the generation born about 1720, and then fell steadily, the figures for eight generations being 5.3, 6.3, 7.7, 10.0, 7.2, 5.5, 4.4, 3.8. This rise is inconsistent with the common hypothesis that social custom is the cause of change in the productivity of races. So also is the form of the surface of frequency of family size in the later decades of the nineteenth century (see *Popular Science Monthly*, May, 1903, p. 68). A real decrease in natural fertility would account perfectly for the statistical appearances found; and, if we judge only by them, is the most likely hypothesis.

Mr. Brues presented a preliminary account of the internal factors of regeneration and reversal of asymmetry in the crustacean *Alpheus*. Przibram and Wilson have recently shown that when the larger of the asymmetrical chelæ of these animals is amputated, the smaller one on the opposite side develops into a claw of the large type, while a small one regenerates on the stump of the large one. If the nerve of the small claw be severed at the time of removing the large one, reversal does not take place, or only incompletely. Histological examination of animals in which such changes are taking place indicates that the regeneration and remodeling are influenced by the nervous system, due possibly to increased nutrition in the ganglion which supplies the small chela. As the nervous system shows no morphological asymmetry corresponding to that of the claws, it probably acts only in a passive way in determining the type of the claw, although it evidently gives the stimuli for the more minute changes which take place in the remodeling of a small chela to form one of the large type.

M. A. Bigelow,
Secretary.

CLEMSON COLLEGE SCIENCE CLUB.

At the meeting of March 20, Dr. J. H. James read a paper on 'Some Facts and Theories in Regard to Dyestuffs.' The history of the processes of dyeing before the latter half of the nineteenth century was briefly told, but the achievements in the preparation of synthetic coloring matters were fully treated. The paper discussed the main points in the synthesis of alizarin and indigo, and the theories relative to the relation between the chemical composition of synthetic dyestuffs and their coloring power. Professor S. W. Reaves presented 'An Historical Note on the Invention of Logarithms,' at the close of which he illustrated the purpose and usefulness of logarithms by well chosen examples. Professor W. M. Riggs exhibited the Clark automatic switch board, the utility of which he demonstrated.

At the meeting of April 17, Professor J. H. M. Beaty presented a paper on 'Some of the More Important Characteristics of the Cotton Fiber.' Professor Beaty spoke of the difficulties encountered in the manipulation of the cotton fiber, and discussed its behavior when treated with dilute caustic potash before bleaching, and the apparent changes when brought in contact with a concentrated solu-

tion of caustic potash for mercerization. The lecture was illustrated with lantern slides as well as the fibers, which were also projected upon the screen.

The annual address before the club and student body was delivered on April 30, by Dr. Henry Louis Smith, of Davidson College, who selected for his subject 'The Intellectual Value of Scientific Training.' In further celebration of the date of organization, a banquet was given by the active members.

At the meeting of May 15, Professor P. T. Brodie gave a paper on 'The Development and Design of the Modern Bridge Truss.' Professor Brodie traced the evolution of the simple truss from the king-post to the types exemplified in the great bridges of to-day. The general criteria for maximum shear and moment from a given system of locomotive and train loading were deduced, and their applications of stress determination as used in the actual design of a Pratt railway bridge were clearly demonstrated. The lecture was illustrated with lantern slides and blackboard drawings.

The following officers have been elected for next year:

President—Chas. E. Chambliss.
Vice-President—R. N. Brackett.
Secretary-Treasurer—F. S. Shiver.

CHAS. E. CHAMBLISS,
Secretary.

DISCUSSION AND CORRESPONDENCE.

THE PROPOSED BIOLOGICAL STATION AT THE TORTUGAS.

TO THE EDITOR OF SCIENCE: I have been much interested in the discussion of the question as to the best place for the location of a tropical marine laboratory for research, which has been going on in the columns of SCIENCE for the past few weeks, and since we are all agreed on the desirability of such a station it is very proper that the problems involved in its establishment should receive careful consideration. I may be pardoned, therefore, if I say a few words in support of Dr. Duerden's contention that Jamaica is the best available place, for although I have never visited the Tortugas, I have spent two weeks in Bermuda, and have made three trips to Jamaica, for zoological purposes.

My experience leads me to believe that a marine laboratory, and especially one in the tropics, ought to be situated where the advantages of civilization are reasonably accessible, and particularly the important one of competent medical assistance in case of accident or disease. We never plan to be sick or to meet with accidents, but we ought not to locate a permanent station where there is no possibility of help when it is most needed. The other advantages of a civilized community, such as good mail and telegraph facilities, good markets and satisfactory means of reaching other places, are of real importance and should not be ignored.

For these reasons the Tortugas seem to me seriously handicapped and even if regular service between them and Key West were maintained, I can not believe that in point of either time or expense, they would be as accessible to students from the central west as are the Bermudas. As between the latter and Jamaica, there can be little question that the larger island has the advantage, not only for the reasons so well presented by Dr. Duerden, but also because of the greater variety and abundance of its marine fauna. Good as is the collecting in Bermuda, it is better in Jamaica, partly because the latter island offers a greater variety of shores and bottoms. While Bermuda is undoubtedly more accessible, and can be reached at less expense, from New York, from all parts of the south and southwest Jamaica can be almost as easily and cheaply reached by means of the excellent steamers from Baltimore. Living expenses in Jamaica are very low, though perhaps not much lower than in Bermuda.

The one claim that is made for the Tortugas is the remarkable abundance and accessibility of the marine life, in both deep and shallow water. While this may be a point in which that station excels Jamaica, I am sure any one who has collected on the reefs of the latter will find it hard to believe that such is the case. But even were it so,

the superior facilities for land and fresh-water work offered by Jamaica are a far more than compensating advantage.

Finally, I should like to emphasize the very great advantage which would come to the laboratory from being located in the midst of such a hospitable community as is to be found in Jamaica. This is a point upon which Dr. Duerden would naturally not care to enlarge, as he was himself for four years a leader in extending courtesies and favors to visiting scientists. The government officials and the officials of the fruit company, which virtually controls communication with the United States, are simply unwearying in their efforts to put the visiting scientist under lasting obligations, and if Jamaica were selected as the site of the proposed laboratory, there is nothing the people there would not do to make the establishment a success, and to convince all comers that there is no place like Jamaica.

Hubert Lyman Clark.

Olivet College,
June, 1903.

SHORTER ARTICLES.

ON THE STRUCTURE OF THE PLESIOSAURIAN SKULL.

An excellent example of a plesiosaurian skull, recently kindly entrusted to me for study by the authorities of the National Museum, confirms so well the rather remarkable determinations of the frontal elements recently published by me, that I desire to make a brief mention of the matter in Science, in anticipation of a more complete description, which may be delayed a year or two. The specimen is from the Eagle Ford Shales, from the vicinity of Austin, Texas, and is, I have little or no doubt, both generically and specifically identical with the type of *Brachauchenius lucasi*, recently described by me from the Cretaceous of Kansas. The specimen lies with its dorsal surface exposed, beautifully supplementing the type specimen of the species now exhibited in the National Museum.

I have no longer any doubt that the so-called frontal bone in all plesiosaurs is in reality a rostral prolongation of the parietal bone, extending forward to meet the premaxilla, and completely excluding the frontals from union in the median line. There is no supraorbital bone, and the so-called postorbital is really the postfrontal, or postfronto-orbital. The nasal has never yet been certainly found as a distinct ossification, but the lachrymal exists as a distinct bone, though often fused with the maxilla.

The study of this specimen confirms my belief that the genus is closely related to *Pliosaurus* of Europe, from which it is distinguished by the entire absence of double-headed cervical ribs. I am, furthermore, convinced that the genus belongs to a family distinct from the true plesiosaurs, and I believe that this family is the Pliosauridæ, hitherto rejected by most students of the order. Whether all the characters given below will apply to the European forms I do not know, since the palatines are *thought* to be separated in *Pliosaurus*, and others may occur in true plesiosaurians. I would, however, define the family as follows:

Pliosauridæ: Skull depressed; no parietal crest; palatines broadly contiguous in the middle line; pterygoids with a prominent ridge and abutting mandibular process. Neck short; cervical ribs single or double headed; all vertebræ without infracentral vascular foramina.

S. W. Williston.

THE REACTIONS OF PARAMŒCIA AND OTHER PROTOZOA TO CHEMICAL AND ELECTRICAL STIMULI.

The recent work of Mathews * on the nature of the chemical stimulation of the motor nerve, and that of R. S. Lillie † on the reaction of nuclear and cytoplasmic structures to the electric current, have greatly strengthened the theory that protoplasm, at least in some of its forms, consists of a colloidal solution whose particles may be either positively or negatively charged.

The present paper is a brief preliminary account of some experiments on the reactions of *Paramœcia* and other protozoa to chemical and electrical stimuli, and the visible changes

*Mathews, Science, XV., 1902, p. 492, and XVII., 1903, p. 729.

† Lillie, *American Journal of Physiology*, VIII., 1903, p. 273.

produced in the protoplasm by these means.

The results of the experiments seem to show that in these forms, also, the colloidal particles in the protoplasm carry a definite electrical charge, and to demonstrate further that the sign of the charge depends directly on certain external conditions surrounding the organism.

The results of a series of experiments carried on last year on the effect of variations in temperature on unicellular animals suggested a very close similarity between the reaction of these organisms to variations in the temperature, and the effects of the same temperature variations on artificial colloidal solutions as observed by Hardy and others. This fact, and especially the conclusions of Dr. Mathews on the chemical stimulation of the nerve, led me to test the effects on the protoplasm of *Paramœcia,* and other protozoa of a series of solutions of acids, bases and salts, with the following results: All the acids and the solutions of all the salts with a predominant positive charge that were used in the experiments, had a common effect on the *Paramœcia,* viz., a coagulation of the protoplasm, and the formation of simple resting cells, similar to those formed by low temperatures. Likewise all bases, and the solutions of all salts with a predominant negative charge, had one and the same effect, viz., a liquefaction of the protoplasm and a stimulation of the metabolic activity of the organism, similar to the effects of a slight increase in temperature. The following solutions carrying a predominant positive charge were used: *m*/800 HCl, H_2SO_4 and HNO_3; *m*/160, *mg* Cl_2, $CaCl_2$, $BaCl_2$ and $Ca(NO_3)_2$; and the following with a predominant negative charge, *m*/800 NaOH, KOH and $Ba(OH)_2$; *m*/160 Na_2SO_4, $(NH_4)_2C_2O_4$, Na_2HPO_4 and $Na_3C_6H_5O_7$. The rapidity and extent of the coagulation or liquefaction vary directly with the valence of the salt. Thus the phosphate and citrate are effective in greater dilutions than the sulphate. The exact figures will be given in the complete paper.

The *Paramœcia* used in the above experiments were taken from cultures which were slightly alkaline in reaction. It was found that if just enough hydrochloric acid was added to the culture to give it a trace of free acid, the reaction of the *Paramœcia* to the salt solutions was nearly reversed. The protoplasm of *Paramœcia* from such an acid culture is either not affected by the solutions of salts with a predominant positive charge, or in some cases is slightly liquefied. But such an acid-modified protoplasm is coagulated in most instances by the solutions of salts with a predominant negative charge. These results agree almost exactly with Hardy's on the acid and alkaline modified colloidal solutions of egg albumen, and lead to the conclusion that in the living protoplasm of *Paramœcium,* as well as in artificial colloidal solutions, the charge which the colloidal particles carry depends directly on the reaction of the surrounding medium.

The chemotaxis of *Paramœcia* from alkaline and acid cultures was tested, and it was found that this response, also, may be reversed by changing the reaction of the culture. For example, *Paramœcia* from an alkaline culture are negative, while *Paramœcia* from an acid culture are positive to weak hydrochloric acid. It thus seems probable that the sense of the chemotropic response of *Paramœcium* depends upon the sign of the charge carried by the protoplasmic particles.

If it is true that the charge on the colloidal particles in the protoplasm of *Paramœcium* may be reversed by changing the reaction of the surrounding medium, then *Paramœcia* in an acid solution ought to show a different response to the electric current from *Paramœcia* in an alkaline solution, and experiments showed this to be the case. *Paramœcia* in an alkaline culture are strongly negative to the electric current. If, however, a few cubic centimeters of the culture containing the *Paramœcia* be isolated in a small dish, and weak hydrochloric acid added, drop by drop, a point is soon reached at which some of the *Paramœcia* begin to swim toward the anode and this reaction may be increased by a further addition of acid until half of the *Paramœcia* show a decided positive response.

Likewise *Paramœcia* which in an acid culture are positive to the electric current may be made to reverse their reaction by gradually neutralizing the acid with sodium hydrate. Lillie has observed a similar relation between the response to the electric current and the condition of the protoplasm, whether acid or alkaline, in his experiments upon nuclear and cytoplasmic structures cited above. He showed that nuclear structures, which contain a large amount of nucleic acid, move toward the anode, while cells very rich in cytoplasm, which is basic in reaction, move in an opposite direction when exposed to the electric current.

It thus appears, from the experiments on *Paramœcia* here outlined, that the conclusions suggested by the work of Mathews and of Lillie are capable of a wider application than has heretofore been given them, and that a definite relation exists between the sign of the charge carried by the protoplasmic particles and certain external conditions surrounding the organism. It also follows from the experiments that by varying these external conditions, we are able not only to reverse the charge carried by the protoplasmic particles, but also the response of *Paramœcium* to certain forms of chemical and electrical stimuli.

A. W. Greeley.

Zoological Laboratory,
Washington University, St. Louis, Mo.,
May 19, 1903.

NOTES ON ENTOMOLOGY.

Mr. W. L. Tower has given an account of the origin and development of the wings of coleoptera.* It is illustrated by seven plates and figures in text. The studies were based on species of various families (mostly phytophagous). He believes that the elytra are homologous to the fore-wings of other insects, the only logical position. As to the origin of the wings his studies lead him to accept Verson's view that the wings are derived from the rudiments of the meso- and metathoracic spiracles. Verson's theory was published in 1890, and based on his study of the silk-worm (*Bombyx mori*). Very substantial objections are advanced by Tower to the two other theories of wing-origin, that of the tracheal-gill origin and that as prolongations of the thoracic tergum. However, his evidence does not show that the ancestors of the Pterygota were terrestrial, and not aquatic.

In a recent number of the *Bericht über Land- und Forstwirthschaft im Deutsch-Ostafrika* are two articles of an entomological nature. One by V. Lommel on the tsetse-fly,* deals with the distribution of this pest in East Africa, and its habits. The other is by Dr. A. Zimmerman† and treats of African coffee insects. The most injurious species is the common coffee leaf-miner (*Cemiostoma coffeella*). An unnamed pentatomid does considerable injury to the coffee beans by puncturing them; quite possibly it gives entrance to some fungus. It seems strange to see a work published in Germany with good figures of insects but without their scientific names, which could easily have been supplied by German entomologists.

The last number of 'Fauna Arctica'‡ contains articles on the hymenoptera, hemiptera and siphunculata of the Arctic regions. The former is by Kiaer and Friese, the latter two by Breddin. There is a good bibliography, and many notes on distribution and time of flight in bees. No new species are described; but there is a fine colored plate representing sixteen species of *Bombus*.

Dr. Otto Schenk, of Jena, treats of the sense organs on the antennal surface of some lepidoptera and hymenoptera.§ He considers the sexual differences in the antennæ of these insects, the structure of the sense organs and their probable function. He arranges these sense organs in several classes, and concludes that most of them are for the detection of odors; but that the *sensilla ampullacea* or 'pits of Forel,' are probably hearing organs.

Dr. L. Melichar has recently completed his monograph of the Flatidæ of the world.‖

* *Zool. Jahrb., Abth. f. Anat.*, 17 Bd., pp. 517–572, 7 pls.

* Bd. 1, Heft 4, pp. 34–350, 1903.

† *Ibid.*, pp. 358–374, 1 pl. (colored).

‡ 'Fauna Arctica,' II., Lief. III., December, 1902.

§ *Zool. Jahrb., Abth. f. Anat.*, 17 Bd., pp. 573–616, 2 pls.

‖ 'Monographie der Acanaloniiden und Flatiden,' Ann. Naturhist. Hofmuseums, Wien, 1902.

Over 90 genera and 525 species are treated. Only about 15 species occur in the United States, although several described by Say are unknown to the author. The Malay archipelago and Madagascar are especially rich in large and curious forms. The article is illustrated by nine plates.

Professor F. Meunier has given us another article on the dipterous fauna of the amber.* He describes species of Tabanidæ, Xylophagidæ, Leptidæ and Empidæ. But what is perhaps of most interest is a diopsid, *Sphyracephala breviata,* very similar to the one species occurring in the eastern United States.

Mr. R. Shelford has published an interesting article on insect mimicry in the Malay region.† There is a systematic arrangement of the cases of Batesian mimicry according to the natural orders, details being given in each case. This is followed by a chapter on convergent groups. Several Müllerian associations are represented, particularly the lycoid, coccinellid, and that of melipona. There is an appendix with descriptions of the new species by various specialists. It is illustrated by five colored plates. The cases figured, as well as those figured by Marshall from South Africa, are no more striking than can be found in the insects of our own country.

THE *Anales Sociedad Espanola de Historia Natural,* Vol. XXX., 1902, contains several entomological articles. Uhagon completes his revision of the Malachidæ of Spain; M. Medina y Ramos gives a synopsis of the Spanish Chrysididæ (101 in number); and A. Martinez y Fernandez-Castillo gives a revision of the group Calopteni of the grasshoppers, treating the known forms of the world; none of which, however, occurs in the United States.

An increase in entomological activity in South America is indicated by Volume V. of the *Revista Museu do Paulista* (São Paulo, Brazil, 1902), which contains three large papers on insects. One of two hundred pages with fine plates is by H. W. Broleman on the myriapoda of the Museum of São Paulo. Another is descriptive of the solitary bees of Brazil. It is by C. Schrottky, synoptic in form, illustrated by two plates, and contains notes on the habits of some species. The third article is by J. G. Foetterle on new Brazilian lepidoptera, illustrated by four handsomely colored plates, and describes fourteen species.

Dr. L. Sander has published a long account of locust invasions of the German colonies in Africa.* The migratorial African grasshoppers are species of *Pachytylus* and *Schistocerca,* the latter similar to those of South America. The author gives an historical account of the ravages of locusts, followed by chapters on structure and life-history. He considers the causes and extension of the migrations, and the various natural enemies, especially birds, that prey upon the pests. A large part of the book treats of remedies, chiefly a history of what has been done in other countries, much attention being given to American methods. An appendix contains an old German edict against grasshoppers.

M. Neveu-Lemaire has devised a new classification of the Culicidæ.† After an historical review he criticizes the classification of Theobald, and proposes his new arrangement based on mouth parts and venation. He divides the family into four subfamilies: Anophelinæ (including only *Anopheles*), Megarhininæ (two genera); Culicinæ (with eight genera); and Aëdëinæ (with six genera). He indicates the type species of each genus.

NATHAN BANKS.

* 'Etudes des quelques Diptères de l'Ambre,' *Ann. Sci. Nat. Zool.,* XVI., December, 1902, pp. 395–405, 1 plate.

† 'Observations on Some Mimetic Insects and Spiders from Borneo and Singapore,' *Proc. Zool. Soc. London,* 1902, II. (1903), pp. 230–281.

* 'Die Wanderheuschrecken und ihre Bekämpfung in unseren afrikanischen Kolonieen,' Berlin, 1902, pp. 344, figs. and maps.

† 'Classification de la famille des Culicides,' *Mém. Soc. Zool.,* France, 1902, pp. 195–227 (1903).

THE HARPSWELL LABORATORY.

THE EDITOR OF SCIENCE asks an account of the Harpswell Laboratory. It is easy to comply, for this biological station is one of the most unpretentious structures one could imagine, as will readily be understood when it is said that the whole plant—land, building

and permanent equipment—has cost within $1,000. A one-story, wooden building, measuring 24 x 42 feet on the ground, with sixteen windows, stands directly on the rocky shore a little to one side of a sandy beach. Inside, the space is divided up into nine rooms for investigators and a larger room accommodating from six to ten more elementary students. At either end are large double doors, and the building is so oriented that in the summer the prevailing southwest wind blows straight through the laboratory, keeping the temperature down on the warmest days. In the past two years there has been but one day when the thermometer has gone above 78° F. in the laboratory.

A considerable portion of the equipment is taken each year from Tufts College, to which institution the laboratory belongs, but there is also something of permanent equipment. Thus the laboratory owns two rowboats, dredges, seines and tangles, abundant glassware, several small microscopes, minor apparatus and the nucleus of a library on morphology and marine biology. The stock of chemicals and reagents is large. It has not yet been found possible to introduce running water into the laboratory, but simple makeshifts have made its absence less of a drawback than might be supposed possible.

The laboratory was established with two objects in view—to furnish a place where the instructors and students of the college could go for summer work, and, second—and this far more important—to ascertain the suitability of the location for a research station for the northern fauna and flora.

As is well known, there are three distinct faunæ on the Atlantic coast of North America—a boreal, a temperate and a subtropical, the last passing into the tropical at the southern end of Florida. The boundaries between these three faunæ are approximately Cape Cod and Cape Hatteras. For the middle or temperate fauna there are already three well-equipped biological stations—the Marine Biological Laboratory and the station of the U. S. Fish Commission at Woods Hole, and the Cold Spring Laboratory of the Brooklyn Institute on Long Island. For the southern fauna there is only the recently erected station of the U. S. Fish Commission at Beaufort, N. C. There certainly should be another farther south, but, having no knowledge of locations and conditions, I am not competent to speak of the merits of the Tortugas advocated in these pages by Dr. Mayer. For the stretch of coast from Cape Cod to Eastport (and extending down into the provinces) there is but the small Harpswell Laboratory.

A few statistics will show the richness and peculiarities of this northern fauna. Before we began our work at Harpswell 517 species of invertebrates had been reported from Casco Bay, this list being largely the result of a single summer's work in the region by the U. S. Fish Commission. In a single haul of the dredge a few miles from our laboratory 118 species were obtained. In the region around Woods Hole, Verrill's report on the invertebrata records 660 species from an area about the size of Casco Bay. Of course, subsequent collections and investigations have largely increased both these lists, but these figures, based upon about the same amount of work, show that this northern region is not far inferior to the other in the number of species.

Another comparison has even more interest. Of the 517 species from Casco Bay 273 are not included in Verrill's list of the invertebrata of Vineyard Sound. In other words, over 52 per cent. of the species occurring in Casco Bay were not then known south of Cape Cod. Of course, since these lists were made up the range of many species has been extended, and forms once known only north of Cape Cod have been found south of that promontory, and hence the percentage mentioned must be altered. Yet it is probable that at least a quarter, if not even a third, of the forms found in Casco Bay are either entirely wanting from or very rare in the waters around Woods Hole.

It is a well-known fact in the distribution of marine life that while the number of species is smaller in colder than in warmer waters, the number of individuals of a spe-

cies increases with the latitude, until, at last, the Arctic regions are noted for the immense numbers of individuals of certain species. Hence, other things being equal, the more northern the spot, the more abundant the material and the better the location for a research laboratory. Therefore, from this one standpoint Eastport may possibly hold the supremacy over other points on the New England coast north of Cape Cod. Its reputation as a collecting ground is great, and, since the days of Stimpson, numerous naturalists have gone there for material.

In the discussion of a location for our laboratory the claims of Eastport were considered, but the place was passed by in favor of South Harpswell for the following reasons: The laboratory must be comparatively easy of access. Students should be able to reach it with the least possible expense and trouble, and there must be adequate market facilities for the boarding places of those working at the laboratory. Eastport may be reached by rail by a long, circuitous and expensive journey, or by boat in twenty-four hours from Boston only on alternate days. Again, the facilities for obtaining board are such that the laboratory, as at Woods Hole, would be compelled to establish its own dining hall, and to maintain it under great difficulties and inconveniences. At South Harpswell there are numerous good hotels and boarding houses and the supplies are of the best. So, too, laboratory supplies, bought with all possible foresight, occasionally become exhausted and must be replenished at short notice. Nothing could be obtained at Eastport in less than two days. Harpswell is distant but two hours from the large wholesale city of Portland, and our experience has been that every chemical and reagent desired could be obtained from there on short notice.

Then, Eastport lies in the very center of the region of fogs, a most serious drawback, not only to the pleasures of life, but to research as well. When all the material studied must be obtained from the sea, it will be readily seen that two or three days of continuous fog might seriously interfere with a piece of research. The farther west on the Maine coast, the less numerous the fogs. At Harpswell, last year, from the middle of June to the middle of September there were only seven days when there was any fog.

Casco Bay is about twenty-five miles across, from Cape Elizabeth to Cape Small Point, and it indents the coast about a dozen miles. This whole area is cut up by numerous peninsulas—'necks' or 'points' of local terminology—and dotted by islands, the number of which passes into the hundreds, affording miles upon miles of shore collecting and between them every variety of bottom. Almost no fresh water empties into the bay, while the considerable tides—about ten feet—cause strong currents, and these bring in constantly—to use a paradoxical expression—the freshest of salt water. South Harpswell itself is at the tip of a narrow neck about ten miles long at just about the middle of the bay. It is fourteen miles from Portland, with which place it is connected, during the summer season, by five boats a day each way.

The laboratory has been practically open but two seasons, and its output of published work is as yet small. The list includes:

A. B. Lamb: 'The Development of the Eye Muscles in *Acanthias*,' *Journal of Anatomy*, Vol. I., 1902.

J. S. Kingsley: 'Preliminary Catalogue of the Marine Invertebrata of Casco Bay,' *Proc. Portland Society of Natural History*, II., 1901.

J. S. Kingsley: 'Additions to the Recorded Fauna of Casco Bay,' *l. c.*, 1902.

Frank S. Collins: 'An Algologist's Vacation in Maine,' *Rhodora*, IV., 1902.

G. M. Winslow: 'Note on the Circular Swimming of Sand Dollar Spermatozoa,' SCIENCE, XVII., 1903.

E. B. Wilson: 'Experiments on Merogony in Nemertine Eggs, with Reference to Cleavage and Localization,' SCIENCE, XVII., 1903.

Here might also be mentioned the paper of Dr. C. B. Wilson, 'On the Embryology of *Cerebratulus*,' and the several papers by Dr. Gilman A. Drew upon the structure and development of the molluscs *Nucula*, *Solemya* and *Yoldia*. The work was done in Harpswell,

but before the establishment of the present laboratory. There are now several important papers in progress, but these can hardly be mentioned until their publication.

In the summer of 1902 considerable attention was paid to the plankton, and almost every night showed novelties and interesting forms. Almost all the common types of larvæ occurred abundantly—*Cyphonautes, Mitraria,* Loven's larva, *Pilidium,* plutei and *Bipinnaria,* etc. More noticeable, however, was *Actinotrocha,* the first time the genus has been noticed north of Newport. On several evenings the rare pteropod *Spirialis gouldii* was abundant, while on others there were numbers of the larvæ of a gymnosomatous pteropod (possibly *Clione*) recalling the oft-copied figures of *Pneumodennon* larvæ. Towards the end of the season several specimens of the strange annelid *Tomopteris,* some with eggs, were taken, and we obtained several specimens of *Arachnactis,* the young of the peculiar sea-anemone, *Cerianthus,* which, by the way, is not uncommon in the deeper waters of the bay. The locality possibly offers a good chance to obtain the development of the Copelate Tunicata, as specimens of an *Appendicularia*-like form, some with apparently ripe eggs and spermatozoa, were abundant. Numerous specimens of chain salpæ were brought us by fishermen from the trawling grounds outside.

The student of elasmobranch embryology will find this a most favorable place for work, for the common dog-fish *Acanthias,* is abundant just outside the islands during most of the summer, and embryos are readily obtained from the first appearance of the blastoderm up to those an inch or two in length.

On the whole, our experience has been that no spot north of Cape Cod can excel South Harpswell as a location for a station for biological research. The present laboratory, while well adapted for elementary instruction, is, in many respects, inadequate to the demands liable to be made upon it when the richness of the fauna and the charms of the place become better known.

J. S. Kingsley.

*THE SOUTH AFRICAN ASSOCIATION.**

The inauguration of the South African Association for the Advancement of Science took place at Cape Town on April 27. The *Cape Times,* to which we are indebted for the details of the proceedings, describes the successful gathering as a British Association meeting in miniature. The new Association enters upon its career with a membership of seven hundred persons from many parts of South Africa.

The main objects of the organization are the same as those of the parent body. As defined in the Constitution, they are "to give a strong impulse and systematic direction to scientific inquiry; to promote the intercourse of societies and individuals interested in science in different parts of South Africa; to obtain a more general attention to the objects of pure and applied science, and the removal of any disadvantages of a public kind which may impede its progress."

The presidential address was delivered by Sir David Gill, K.C.B., the Astronomer Royal for South Africa, who explained the nature of the work which it was hoped the new Association would accomplish. During the course of his able address Sir David Gill announced that Lord Kelvin had written that, although in 1905 he will be eighty-one years of age, he intends, if he is as well then as he is now, to accompany the British Association on the visit to South Africa.

The work of the sections began on the second day of the meeting. The presidential addresses in the various sections were delivered by the following men of science:

Section A, Astronomy, Chemistry, Mathematics, Meteorology and Physics, by Profesor P. D. Hahn; Section B, Anthropology, Ethnology, Bacteriology, Botany, Geography, Geology, Mineralogy and Zoology, by Dr. R. Marlotti; and Section C, Archeology, Education, Mental Science, Philology, Political Economy, Sociology and Statistics, by Dr. Thomas Muir, C.M.G., F.R.S., Director of Education for Cape Colony.

Among the papers read during the course of the meetings the following deserve mention. In Section A, on ferments causing 'casse' in wine, by Mr. Raymond Dubois; meteorology in South

* From *Nature.*

Africa: a retrospect and prospect, by Mr. C. M. Stewart; close binary systems, by Dr. Alex. W. Roberts; determination of mean temperature, etc., from observations made at second-order stations on the Table Land, by Mr. J. R. Sutton; some recent work on the discharge of electricity from heated bodies, by Professor J. C. Beattie.

In Section B, (1) on the occurrence of an epidemic among the domesticated animals in Mauritius in which Trypanosomata were found in the blood; (2) note on the correlation of several diseases occurring among animals in South Africa; (3) on the production of a malarial form of South African horse sickness, by Dr. Alex. Edington; the minerals of some South African granites, by Mr. F. P. Mennell; on the classification of the Theriodonts and their allies, by Dr. R. Broom; (1) some morphological and biological observations on the genus *Anacampseros;* (2) on some stone implements in the Albany Museum, by Dr. S. Schonland.

In Section C, some aspects of South African forestry, by Mr. D. E. Hutchins; dry crushing of ore preparatory to the extraction of gold, by Mr. Franklin White; sewage disposal in Cape Colony, by Mr. J. Edward Fitt.

In Section D, the library system of South Africa in comparison with those of England and America, by Mr. Bertram L. Dyer; iteration as a factor in language, by Professor W. Ritchie; common sense and examination, by Mr. P. A. Barnett; Cape Dutch, by Professor W. S. Logeman; how we get knowledge through our senses, by Rev. Dr. F. C. Kolbe.

The example set by the British Association of arranging for receptions and other social functions to lighten the intellectual fare provided was followed at Cape Town, and the excursions, conversazioni, etc., were well attended and much appreciated.

SCIENTIFIC NOTES AND NEWS.

THE University of Pennsylvania has conferred its Doctorate of Laws on Dr. Charles D. Walcott, director of the U. S. Geological Survey, and on Dr. F. P. Venable, now president and formerly professor of chemistry at the University of North Carolina. The university has conferred its doctorate of science on Colonel William Gorgas, U.S.A.

COLUMBIA UNIVERSITY has conferred the degree of Doctor of Science on Dr. J. J. Thomson, Cavendish professor of physics at Cambridge University, and on Mr. Peter Cooper Hewitt, known for his researches and inventions in electrical science.

OXFORD UNIVERSITY will confer its Doctorate of Science on M. Henri Poincaré, professor of mechanics at Paris, and on Mr. M. H. N. Story-Maskelyne, formerly professor of mineralogy in the university.

BY a vote of the Corporation of Harvard College a bronze tablet has been placed in the Museum of Comparative Zoology under the portrait of Dr. Alexander Agassiz. The tablet bears this inscription: 'Alexander Agassiz. This memorial of his great services to science and the University, given by his friends, is placed here by special vote of the President and Fellows and Board of Overseers.'

THE Albert Medal of the Society of Arts, London, for the year 1903, has been awarded to Sir Charles Augustus Hartley, K.C.M.G., in recognition of his services, extending over forty-four years, as engineer to the International Commission of the Danube, which have resulted in the opening up of the navigation of that river to ships of all nations, and of his similar services, extending over twenty years, as British commissioner on the International Technical Commission of the Suez Canal.

A CHAPTER of the scientific society of the Sigma Xi has recently been organized at the University of Michigan with Professor J. P. McMurrich as president.

ACCORDING to the *American Geologist* Mr. Bailey Willis has accepted the position of leader of the Carnegie Geological Expedition to China, which has as its object the investigation of the Cambrian of that country. He will be assisted by Mr. Eliot Blackwelder, of the University of Chicago. Mr. Willis expects to leave Washington in July, to attend the International Congress of Geologists at Vienna, and to go to China *via* Siberia. Dr. H. Foster Bain has accepted an appointment as geologist on the United States Geological Survey, and during Mr. Bailey Willis's absence in China will be acting editor of geologic folios. He is to take up the study of

the lead and zinc deposits of the Mississippi valley, and during the coming summer will make special investigations concerning the deposits in southern and northwestern Illinois.

General A. W. Greeley, chief of the U. S. Signal Service Office, has returned to the United States after attending the International Telegraphers' Conference in London.

Professor F. E. Lloyd, of Teachers College, Columbia University, left June 13, by the Steamer *Caribee* for the island of Dominica, where, in the company of Mrs. Lloyd, he will spend the summer in the study of the flora. The expedition is being conducted under the auspices of the New York Botanical Garden. The systematic collections will become a part of the garden herbarium. Professor Lloyd has received a grant of $200 from the Esther Herrman research fund of the Scientific Alliance of New York, to aid him in the collection of tropical Rubiaceae to be used in the furtherance of his researches in the embryology of that order.

Professor and Mrs. Robert H. Richards, of the Massachusetts Institute of Technology, left Boston on June 14 to make a tour of inspection of the principal centers of the mechanical preparation of low grade ores on the Pacific coast.

Professor John C. Merriam, of the University of California, has returned to Berkeley from the fossil beds in Idaho.

Mr. George G. MacCurdy, curator of the anthropological collections of the Peabody Museum, of Yale University, has sailed for Europe, where he will make purchases for the museum.

Messrs. A. F. Blakeslee and J. R. Johnston, of the Graduate School of Harvard University, will spend the summer vacation on Trinidad island for the purpose of collecting botanical specimens for the university.

Silas P. Beebe, M.S., who has been engaged in research work in the laboratory of physiological chemistry in the Sheffield Scientific School of Yale University, has been appointed physiological chemist in connection with the Huntington Fund for Cancer Research in the Loomis Laboratory, New York.

Dr. John Gifford, of the New York State College of Forestry, has tendered his resignation as assistant professor of forestry. He will leave in a few days to investigate the reservation in Porto Rico for the Bureau of Forestry.

Mr. Albert Kingsbury, professor of applied mechanics, at the Worcester Polytechnic Institute, has resigned in order to accept a position as mechanical engineer with the Westinghouse Electrical and Manufacturing Company of Pittsburgh.

Leo F. Rettger, Ph.D., instructor in bacteriology in the Sheffield Scientific School of Yale University, sailed for Europe on June 10. He will spend some time at Strasburg studying bacteriology and bacteriological chemistry.

The Geological Society, London, has made the first award of the proceeds of the fund founded by the late Mr. Daniel Pidgeon, F.G.S., to Dr. Ernest Willington Skeates, of the Royal College of Science.

A committee of eminent chemists has been formed to erect a monument at Heidelberg in memory of Robert Bunsen. It is intended that the contribution shall be international and may be sent to the treasurer, Herr A. Rodrian, Heidelberg.

A portrait of Dr. David Little, formerly lecturer of ophthalmology in Owens College, Manchester, was unveiled on May 27.

Dr. A. A. Common, F.R.S., president of the Royal Astronomical Society in 1895, well-known for his important researches in astronomy, especially in connection with reflecting telescopes, died on June 2, at the age of sixty-two years.

The famous paleontological collection of the Baron de Bayet, of Brussels, Belgium, has been purchased by Mr. Andrew Carnegie and presented by him to the Carnegie Museum at Pittsburgh. It is a vast collection, exceedingly rich in reptilia, fishes, invertebrates and plants from almost all the classic localities in Europe. There is a splendid series of Rhamphorhynchus, Teleosaurus, Ichthyosaurus, Pterodactylus, Mosasaurus and

other colossal reptiles. The collection of Chelonians is large. There are five skeletons of *Crocodilus vicentinus* from Italy. A thousand species of fossil fishes are represented, among them a splendid assemblage of specimens from the old red sandstone of Scotland. There is a splendid collection of fossil insects from Solenhofen, and a number of magnificent slabs showing the palm trees of Monte Bolca. One slab has upon it the stem, roots and seven leaves of a dwarf palm. There has been hitherto no representative collection of the fossils of Europe on this side of the Atlantic, and the acquisition of this splendid and very costly collection at one stroke puts the section of paleontology of the Carnegie Museum in a position to make it a point of central attraction to American students, who may desire to institute comparisons between the extinct fauna and flora of Europe and America.

THE exhibition room on the second floor of the Peabody Museum, Harvard University, formerly used for the Semitic collections, has been fitted with ethnological collections, mostly relating to the Indian tribes along the west coast of America.

THE British Anatomical Society will hold its summer meeting this year at University College, Liverpool, on June 19 and 20.

A MEETING of the council of the International Association of Academies was held during the first week of this month, at the rooms of the Royal Society, that society being the directing academy of the association for the three years' period ending with 1904. *Nature* states that the meeting was attended by delegates from nearly all the principal learned academies of Europe, who discussed several matters of importance to international science and philosophy, preparatory to the meeting of the general assembly which is to be held in London next year. Representatives of both sections of the association, the natural science section and the history and philosophy section, attend the council. In connection with the meeting of the council there was a meeting of a special committee appointed to deal with a proposal for the establishment of an international organization for the investigation of the anatomy of the brain. The foreign delegates were received by the president and fellows of the Royal Society at Burlington House on June 3.

THE International Congress for applied chemistry was formally opened on June 3. We learn from notices in *Nature* and the *Times* that Geheimrath Professor Dr. Otto Witt presided, and there was a large gathering of leading authorities on chemistry from all parts of the world. Speeches were delivered by Count Posadowsky, Imperial Secretary of State for the Interior, and Dr. Studt, Prussian minister of education. They referred to the enormous importance of applied chemistry both for industry and agriculture, and instanced among other achievements the development of the production of beetroot sugar. Dr. Studt stated that in Germany alone chemical industries created products to the value of more than one milliard of marks. Among the foreign delegates who spoke were Professor Moissan, president of the Paris Chemical Society, Professor Tilden, of the Royal College of Science of London, Professor Ludwig, from Vienna, and Professor Jakobkin, from St. Petersburg. About 2,200 members were present. The Congress was divided into eleven sections and three subsections. The German Electrochemical Society, which last year adopted the name of German Bunsen Society for Applied Physical Chemistry, also held its annual meeting at Berlin during the week, and took charge of the electrochemical section. There were 350 papers and reports on the program.

THE Civil Service Commission will hold a competitive examination during the summer or fall to fill a position as assistant chemist in the Geological Survey, salary $1,200. No applicants who are unable to do independent research work in mineralogy and crystallography will be considered. Ability to do independent chemical research work, while desired, is not an essential condition, although a good knowledge of analytical chemistry is demanded. For information as to dates and places for holding the examination and sub-

jects to be covered applicants should address the Civil Service Commission at Washington. It is probable that another position as assistant chemist will be open to competition in the Geological Survey during the summer. The position is one paying $1,800 per annum. Only a fair knowledge of mineralogy will be required of applicants for it, but they must be men of experience, well versed in chemical analysis, and able to do independent work on problems relating to geology. The examination in this latter case will not be of the usual kind, but the markings will be based on education and technical experience, a thesis of a thousand words and published work. As the filling of this position is not yet in the hands of the Civil Service Commission, inquiries and addresses should be sent to the director of the Geological Survey, at Washington.

THERE will be a civil service examination on July 29 and 30 to fill positions of assistant engineers and hydrographers in the U. S. Geological Survey at a salary of $60 a month.

Nature states that the twenty-first congress of the Sanitary Institute will be held at Bradford on July 6–11. The inaugural address to the congress will be delivered by the president, the Right Hon. the Earl Stamford. Numerous sectional meetings will be held, the sections with their presidents being as follows: (1) Sanitary science and preventive medicine, Professor T. Clifford Allbutt, F.R.S.; (2) engineering and architecture, Mr. Maurice Fitzmaurice, C.M.G.; (3) physics, chemistry and biology, Professor C. Hunter Stewart. On July 8 there will be conferences of those engaged in the various branches of practical sanitary science, and in the evening a *conversazione* and reception by the mayor of Bradford. The concluding day will be devoted to excursions.

THE report by Dr. Joseph Struthers to the United States Geological Survey on sulphur and pyrite in 1902 is now in press. The production of sulphur in the United States in 1902 was 8,336 short tons, valued at $220,560, as compared with 7,690 tons, valued at $223,430, in 1901, and 3,525 tons, valued at $88,100, in 1900. The production in 1902 was derived from Louisiana, Nevada and Utah, in the order of the importance of their output. Oregon and Idaho, which contributed to the output during 1901, reported no production for 1902. The quantities of sulphur produced in the United States during 1901 and 1902 are the largest annual outputs that have been recorded. Up to 1901 the production of domestic sulphur averaged less than one per cent. of the total consumption, an insignificant amount compared with the foreign imports, which amounted in 1902 to 174,939 long tons. The quantity of sulphur consumed in the United States from foreign and domestic sources, including the sulphur content of iron pyrite, which is used in the manufacture of sulphuric acid, amounted to 510,106 long tons. By far the greater part of the sulphur consumed in the United States is used in the manufacture of paper stock by the sulphite process. The production of pyrite in 1902 reached the largest annual output yet attained in the United States, 290,973 long tons, valued at $1,219,210, exceeding the previous record in 1901 of 234,825 long tons, valued at $1,024,449, by 23.9 per cent. in quantity and 19 per cent. in value. Of the total output, Virginia contributed nearly one-half, followed by Georgia and North Carolina, Colorado, Massachusetts, California, Indiana and Ohio, Missouri and New York, in the respective order of the quantities of output. In addition to the large increase in the production of pyrite in the United States during 1902, there was a very large increase in the quantity of pyrite imported, the statistics of imports for 1902 and 1901 being respectively 440,363 long tons ($1,650,852) and 403,706 long tons ($1,415,149). The increased use of pyrite for acid making has been due both to the development of the sulphite wood-pulp industry for manufacturing paper and to the increased domestic manufacture of superphosphates, consequent upon the increased production of phosphate rock from Florida and Tennessee.

AT a special meeting of the Physical Society, held in London, on June 8, with the president, Dr. R. T. Glazebrook in the chair, Professor E. Rutherford, of McGill Univer-

sity, Montreal, read a paper on 'Radio-active Processes.' According to the report in the London *Times* he pointed out that the radio-active bodies uranium, thorium and radium were continuously and apparently spontaneously giving off three distinct types of radiation. There were, first, the α rays, which were projected bodies, flights of positively charged material particles, which were prominent in causing conductivity in gases, were easily absorbed, moved with great velocity, and carried a large amount of energy. Secondly, there were the β rays, which were apparently the same as the cathode rays of ordinary vacuum tubes, though they traveled faster, and hence had very considerable penetrating powers. They were negatively charged. Thirdly, there were the γ rays, which appeared very similar to ordinary X-rays. In addition some of the substances gave off something else. Thorium oxide, for example, emitted an emanation which appeared to be matter in gaseous state, and could be carried along by air-streams, and radium gave a similar emanation, which differed from that of thorium in that its effects were far more persistent. These emanations behaved like radio-active gases; their diffusion could be measured, and they could be occluded in radio-active bodies, while the fact that they could be condensed by the cold of liquid air rendered them difficult of explanation except on the assumption that they consisted of material bodies. These emanations induced or excited radio-activity in every body in their neighborhood, and this excited activity, like that of the emanations, decayed at a constant rate. Apparently the emanations themselves could not be affected by any chemical treatment, but behaved like inert gases, wherein they differed from the excited activity which chemical treatment did affect. It had been found possible to separate from radio-active bodies a radio-active constituent; thus by a chemical method Crookes had removed all activity from uranium, and the lecturer and Mr. Soddy had found that the radio-active constituent, which might be called thorium X, could be separated from thorium. In time, however, the former lost its activity and the latter regained it. It seemed as if radio-active bodies were continually undergoing some change by which new substances were being produced; thus thorium from which all the thorium X had been removed would in a few weeks yield as much as before. The radiations had a close connection with chemical changes. It might be supposed that the atoms of the radio-active bodies were in a state of unstable equilibrium, and sent off positively charged bodies. But the thorium atom which had sent off such a positive body was chemically altered, and thorium X was equivalent to thorium *minus* the expelled body. The thorium X atom was also unstable, and in turn threw off another positive body, and so the process went on, the changes that occurred being measured by the activity of the preceding stage. The main radio-active processes threw off positive bodies, which were thus the most important, and negative electrons and cathode rays only appeared in the last stages. It was to expected that only a small number of α rays would be thrown off; these were quickly absorbed, and thus the radium was subject to bombardment by itself, with the result that it grew hot and maintained its temperature above that of its surroundings, as observed by Curie. The amount of energy given out was enormous; it might be calculated that a gram of radium during its life would give out enough to raise 500 tons a mile high. But there was no reason why such huge stores of energy should be thought to exist only in radio-active bodies; they might exist in every atom, although we had not yet happened to obtain any knowledge of their existence.

UNIVERSITY AND EDUCATIONAL NEWS.

PRESIDENT BUTLER announced at the commencement exercises of Columbia University that the trustees had decided to purchase the two blocks of land south of the present site of the university at a cost of $2,000,000. He also announced a gift of $300,000 from Mrs. Helen Hartley Jenkins and Mr. Marcellus Hartley Dodge, a member of the senior class,

for a dormitory; and of $100,000 from General Horace W. Charpentier for the School of Law, part of which is to be used for the establishment of special lectures on the science of law.

Boston University has received a gift of $100,000, which will be used to purchase the building on the corner of Somerset street and Ashburton place.

Harvard University has established a course in forestry, and Mr. R. T. Fisher has been appointed instructor in this subject.

Trustees have been appointed to the newly organized University of Porto Rico.

Union College is one of the very few reputable institutions which persists in conferring the degree of Ph.D., *honoris causa*. It has conferred the degree this year on one of our most eminent electrical engineers, who is incidentally professor at the college.

A correspondent has sent us a circular letter from the American National Nashville College of Law, offering to bestow upon him the degree of Doctor of Laws on the payment of a fee of $10. This extraordinary institution announces that it has increased its authorized capital stock from $10,000 to $20,000 to enable it to offer courses leading to the degrees of D.C.L. and LL.D. It claims to be incorporated by the commonwealth of Tennessee.

At the commencement exercises of the University of Colorado, at Boulder, degrees were conferred as follows: B.A., 10; B.S., 11; B.Ph., 7; B.S. (C.E.), 5; B.S. (E.E.), 8; M.D., 8; LL.B., 11; M.A., 4. At the same institution Professor R. D. George, assistant professor of geology at the University of Iowa, has been called to a full professorship of geology.

Dr. Charles S. Palmer has resigned the presidency of the Colorado State School of Mines and will be succeeded by Dean Victor C. Alderson, of the Armour Institute of Technology.

Dr. H. B. Fine, professor of mathematics of Princeton University, has been elected dean.

Dr. Charles Palache, assistant professor of mineralogy at Harvard University, and Dr. J. R. Angell, associate professor of experimental psychology at the University of Chicago, will lecture in the summer school of the University of California.

The following promotions and appointments are announced at Harvard University: Professor Charles R. Sanger, director of the chemical laboratory; Robert W. Willson, professor of astronomy; W. Ernest Castle, assistant professor of zoology; G. W. Pierce and Theodore Lyman, instructors in physics; Assistant Professor H. A. Torrey, of the University of Vermont, instructor in chemistry; J. F. Langmaid, assistant in chemistry; W. S. Tower, assistant in physiography and meteorology; J. M. Greenman, instructor in botany.

Dr. Frederick Neher and Dr. Alexander H. Phillips, of Princeton University, have been promoted to professorships of analytical and organic chemistry and of mineralogy respectively.

Dr. J. Heath Bawden has been promoted to the professorship of philosophy, Vassar College.

Joseph E. Kirkwood, Ph. D. (Columbia), instructor in botany, and Albert M. Reese, Ph.D. (Johns Hopkins), instructor in histology and embryology, have been promoted to associate professorships in Syracuse University.

The following appointments have been made in the Chemical Department of the University of North Carolina for the session 1903–4: R. O. E. Davis, Ph.D, instructor; W. McKim Marriotte and L. B. Lockhart, assistants; Reston Stevenson, M.A. (North Carolina), has accepted a position of assistant in chemistry, Cornell University; H. H. Bennett, Ph.B., assistant in chemistry, has accepted an assistantship in the Soil Survey Laboratory, Washington, D. C.

Miss Onera A. Merritt, who holds degrees from Birmingham and London Universities, has been appointed instructor in zoology at Wellesley College.

F. A. Sager, assistant professor of physics in the University of Illinois, has resigned.